

REMARKS

With the entry of the present Amendment, Claims 1-7, 10-19 and 69-87 are pending in this application. Claim 1 has been amended, and Claims 69-87 are newly added. Claims 8, 9, and 20-68 are cancelled. No new matter has been added.

It is believed that the present claims are all in condition for allowance. Specifically, Claim 1 now recites a method of phase-shifting a beam from an electromagnetic beam source in a lithographic process that comprises focusing a beam onto a mask having a primary feature and one or more assist features, where the assist feature(s) are configured such that, when an electromagnetic beam passes through the mask, opposing electric fields generated at the primary feature and at the one or more assist features balance to substantially eliminate the electric field at the zero frequency at the primary feature, and where the mask is adapted to selectively phase-shift at least a portion of the beam according to a predetermined pattern. The method further includes the steps of passing the beam from the electromagnetic beam source through the mask producing a phase-shifted beam having substantially no zero-order light; and directing the phase-shifted beam at a substrate adapted to image the primary feature.

The method of Claim 1 is known as a “strong” phase shifted imaging process in that the opposing electric fields of the primary and assist features are balanced to minimize or eliminate the electric field at the zero frequency of the primary feature. As noted in the present specification, a strong phase shifting technique has several advantages over conventional methods in that it restricts interference angles needed to reconstruct the image in a way where their phase relationship is maintained, thus improving performance during changes in focus and exposure, and during other aberrations. (See Specification at p. 3, line 23 through p. 4, line 7).

The method of Claim 1 is not taught or suggested by any of the prior art of record in this case. The cited Kamon (U.S. Pat. 5,229,230) and Yasuzato (U.S. Pat. 6,004,699) references fail to teach or suggest a mask having primary and assist features where the assist features are configured such that, when an electromagnetic beam passes through the mask, opposing electric fields generated at the primary feature and at the one or more assist features balance to substantially eliminate the electric field at the zero frequency at the primary feature. These

references also fail to teach or suggest passing electromagnetic radiation through the mask to produce a phase-shifted beam having substantially no zero order light. In fact, Kamon actually teaches away from Claim 1 where it states that “the Fresnel diffraction light from the auxiliary patterns and the zero-order diffraction light from the rectangular light-transmission pattern intensify each other at a position where a pattern corresponding to the rectangular light transmission pattern is formed on the resist film.” (See col. 2, lines 9-14). This is in stark contrast to Claim 1, which states that the mask pattern substantially eliminates the zero-order light. In addition, while the Yasozato reference discusses a photomask used for projection exposure having phase-shifted auxiliary features, it does not teach or suggest a mask configured such that opposing electric fields generated at the primary feature and at the one or more assist features balance to substantially eliminate the electric field at the zero frequency at the primary feature. Yasozato also fails to teach or suggest passing electromagnetic radiation through the mask to produce a phase-shifted beam having substantially no zero order light.

Since the method of Claim 1 is not taught or suggested by the art, it is respectfully submitted that Claim 1 and its dependents, Claims 2-7 and 10-19, should be allowed.

In another aspect, the present invention relates to a method of forming a phase-shift mask employing photomask topography and resist sensitivity to electromagnetic radiation. As recited in newly-added Claim 69, the method comprises determining a proposed pattern layout for a phase-shift mask comprising a primary feature and one or more assist features; analyzing, in a frequency domain, the phase and amplitude of a diffraction pattern of the proposed mask pattern via a Fourier transform; and based upon the analysis step, adjusting a physical characteristic of the primary feature or an assist feature, and repeating the analyzing and adjusting steps until a final mask pattern is determined in which opposing electric fields generated at the primary feature and at the one or more assist features balance to produce a desired amount of zero-order light for a selected imaging application. The method provides a systematic technique for layout and fabrication of a phase-shift feature that permits tuning of the complex transmittance and phase of the features to yield the correct amount of zero-order light for the application, while maintaining design rules to that the photomask can be manufactured in a reliable fashion. Support for amended Claims 69-87 can be found in the Specification at, for example, p. 4, line 8 through p. 5, line 28; p. 17, line 12 through p. 19, lines 15; and Fig. 10.

It is believed that independent Claim 69 is allowable over the prior art of record, since none of the references cited by the Examiner teach or suggest a method that includes analyzing, in a frequency domain, the phase and amplitude of a diffraction pattern of a proposed mask pattern via a Fourier transform, and then adjusting the physical characteristics of the primary and assist features until the design yields the proper amount of zero-order light for the lithographic process. Since the method of Claim 69 is not taught or suggested by the art, it is respectfully submitted that Claim 69 and its dependents, Claims 70-87, should be allowed.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned at (978) 341-0036.

Respectfully submitted,

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MARKED UP VERSION OF AMENDMENTSClaim Amendments Under 37 C.F.R. § 1.121(c)(1)(ii)

1. (Amended) A method of phase-shifting a beam from an electromagnetic beam source in a lithographic process comprising:
 - focusing a beam from the electromagnetic beam source onto a mask having a primary feature and one or more assist features proximate to the primary feature, the one or more assist features configured such that, when an electromagnetic beam passes through the mask, opposing electric fields generated at the primary feature and at the one or more assist features balance to substantially eliminate the electric field at the zero frequency at the primary feature, the mask adapted to selectively phase-shift at least a portion of the beam according to a predetermined pattern;
 - passing the beam from the electromagnetic beam source through the mask producing a phase-shifted beam having substantially no zero-order light; and
 - directing the phase-shifted beam at a substrate adapted to [be selectively etched according to the predetermined pattern] image the primary feature.